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OBSERVATION OF ULTRAWEAK LUMINESCENCE OF ORGANISMS IN DIFFERENT GASES AND SUBJECT TO IONIZING RADIATION AND TEMPERATURE EFFECTS

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After the ultraweak luminescence of living organisms was observed [1, 3], the literature carried descriptions of installations [2, 4] and systems which made it possible to record chemiluminescence by deep freezing the photoelectric electron-multiplier tube. Then with the appearance of photoamplifiers with low thermal noise, [5,6] for the first time use was made of the photoelectric electron-multiplier tube (hereafter FEM) 42 without cooling which made it possible to extend the number of studies devoted to ultraweak luminescence. Although one can find in the literature descriptions of installations without cooling but with magentic defocusing, in this type the surface of the photocathode is reduced and thus the characteristics of the FEM are reduced in quality. All the apparatus described which earlier satisfied researchers must now be more universal and meet broader requirements.

These requirements include a wide range of simultaneous effects on the test organism by various physical and chemical factors, such as various gases, temperature, irradiation, etc.

The devide which we conetructed makes it possible to record chemiluminescence of biosubstrates under the simultaneous effects of various gases, temperature and X-rays. By using this apparatus it is possible to maintain a pressure of up to 30 atmospheres in the recording chamber. This makes it possible to trace the oxygen effect, the temperature coefficient, chemiluminescence and to work with various protectors in X-ray work. Not all the results achieved and shown in this work indicate that this apparatus makes it possible under a combination of factors to record chemiluminescence from a distance by using light guides of different designs made of organic optical glass.

There is no doubt but that such an apparatus will make it possible to expand our concpet of the biological effect of ionizing radiation in atmospheres of different gases and temperatures over a broad range and carry out synthesising studies in the field of bioluminescence.

In Fig.1 we have the design of the basic gas chamber with an 0.8 liter capacity. It consists of five basic units: the chamber 31, the light guide 18, the electromagnet 1-10, the heating plate 36 and the PEM-42 17. The chamber is a bronze cylinder with an inner diameter of 100mm. At the fore end it is covered with a metal cover held on by bolts 30. To the rear of the main chamber is attached a copper cylinder 41 with a diameter of 80mm and a length of 380mm. Inside the cylinder axle 47 is rotated on teflon bushings by a servomotor 52 which sets the experimental plate 43 in motion. In order to reduce to a minimum the effect of the X-rays on the photomultiplier, the light guide and the entire chamber except for the copper cylinder in the rear are mounted in a lead housing.

Inside the main chamber is heating plate 36 which is connected to a thermostat by tube 34. On the right side of the chamber are pipes 24 with branch tubes 23 to feed in the gases.

In order to control the temperature of the test object thermal sensor 33 is installed inside the chamber. The most responsible link in the system is the light guide 18 which inside a conical housing and fastened so that it will not move upward under critical pressures. The light guide is made of optical plexiglass with minimal light absorption. Although Garvin, Harris and Bell [9, 10] have described light guides where the light yield is 70-80%, our design has greater resolution and produces a yield of light quanta of the order of 90%. The point of contact of the PEM with the light guide is smeared with optical glycerine.

In order to maintain a constant operating cycle for the PEM during prolonged measurement it is desirable not to turn off the current of the PEM. In order to cut out light on the PEM when the foreward cover of the chamber is open, a metallic blind 29 is fitted inside the chamber in front of the light guide. The movement of the blind is controlled remotely by means of an electromagnet. When the blind shuts, contact 26 turns on the right electromagnet. After the cover of the chamber closes, the left coil of the electromagnet is turned on and the blind slides back, thus opening the way for the passage of the light quanta through the light guideto the PEM cathode. As we can see from Fig. 1 the coupling of the electromagnet and the servomotor rotor are also under pressure. In this design the electromagnet coupling has no contact with the inner environment and light cannot enter the chamber from outside.

For safety reasons the servomotor rotor is separated from the stator by a cylinder and thus the rotor is under pressure. All the bushings inside the chamber are made of fluoroplast. This can be explained as due to the fact that rotating mechanisms lubricated with oil cannot operate in an oxygen atmosphere.

Fig. 1 Design of a gas chamber.[See next page]
A - view from the front.
1 - stopper bolt; 2 - gasket; 3 - antishock liner; 4 - electromagnet winding; 5 - magnetic circuit; 6 - electromagnet coil; 7 - guide tube; 8 - electromagnet core; 9 - lead outs; 10 - forward stopper bolt; 11 - electromagnet coupling; 12 - gasket; 13 - holder; 14 - signal contacts; 15 - upper guide blinds; 16 - light guide holder; 17 - PEM; 18 - light guide; 19 - PEM housing; 20 - flange; 21 - flange for fastening PEM housing; 22 - transport tube; 23 - gas tube; 24 - tube for feeding gas; 25 - blind socket; 26 - signal tube contact; 27 - fastener for contact; 28 - lower guide blinds; 29 - blind; 30 - pegs for fastening forward cover; 31 - chamber case; 32 - insulation for thermoresistor contact; 33 - contacts; 34 - branch tube for heater; 35 - silencer; 36 - thermostat plate.

After the test substance in dish 42 is placed in the main chamber on the experimental plate 43, chamber cover 28 is closed; the motor is turned on and the dish moves from the experimental plate to the end of the copper cylinder 41. In this position special contacts in the chamber are closed, and tube L_5 is opened (Fig.2) which has a relay P_4 in its anode circuit. By means of the first pair of relay P_4 contacts the signal tube L_1 turns on, indicating that the dish is ready for irradiation. Irradiation is produced by apparatus RUM-11 which is installed above the dish and fastened solidly to the copper cylinder. During irradiation the 3mm walls of the cylinder also serve as a filter for the X-rays. Dosage in the chamber is 45r per minute.

Fig. 1 [See page 5]
B - Side view
37 - tube for injecting and exhausting gases
38 - chamber cover
39, 48, 51, 56 - fluoroplast bushings
40
41
44

47 - drive axle
49 - cylinder rear cover
50 - reducer
52 - motor axle
53 - stator
54 - rotor
55 - additional rotor yoke

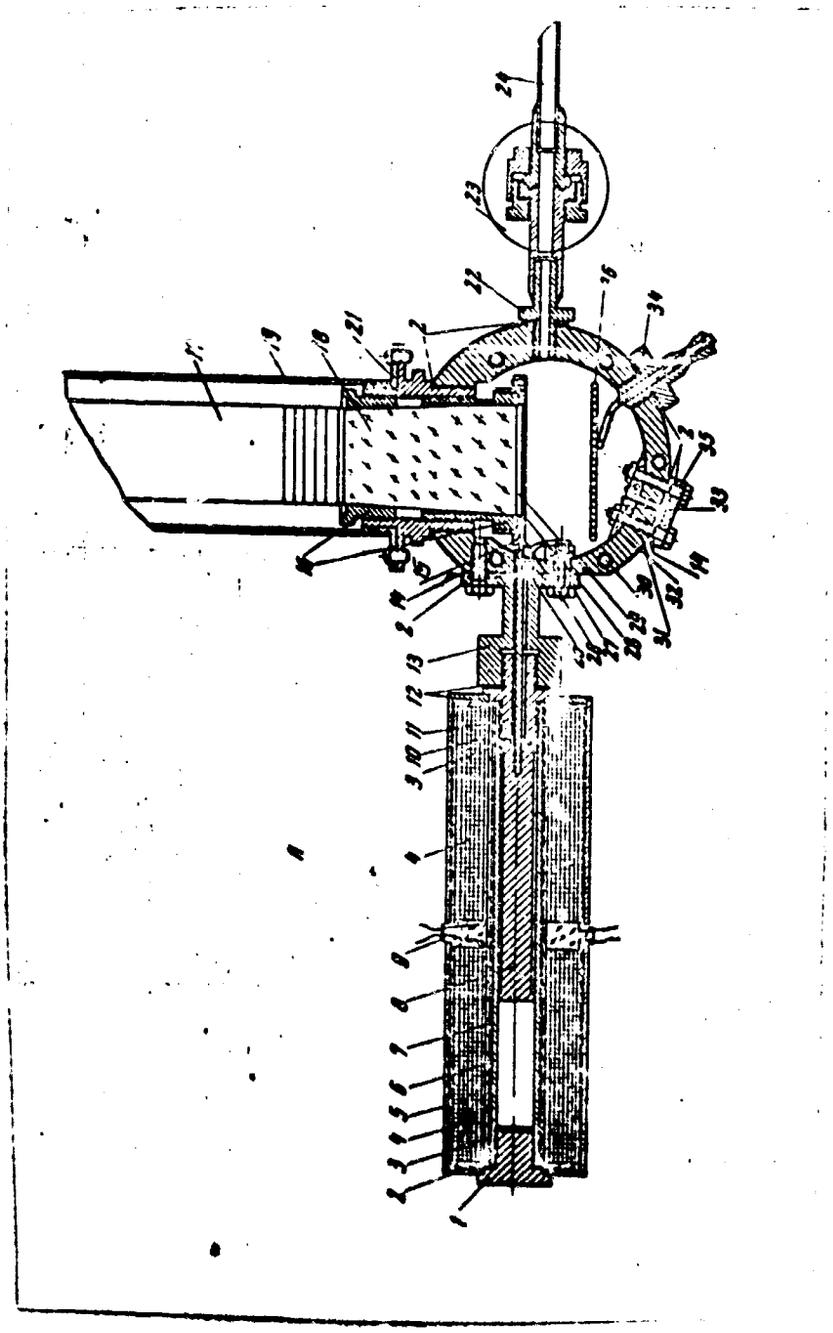

Fig. 1 (1/2)

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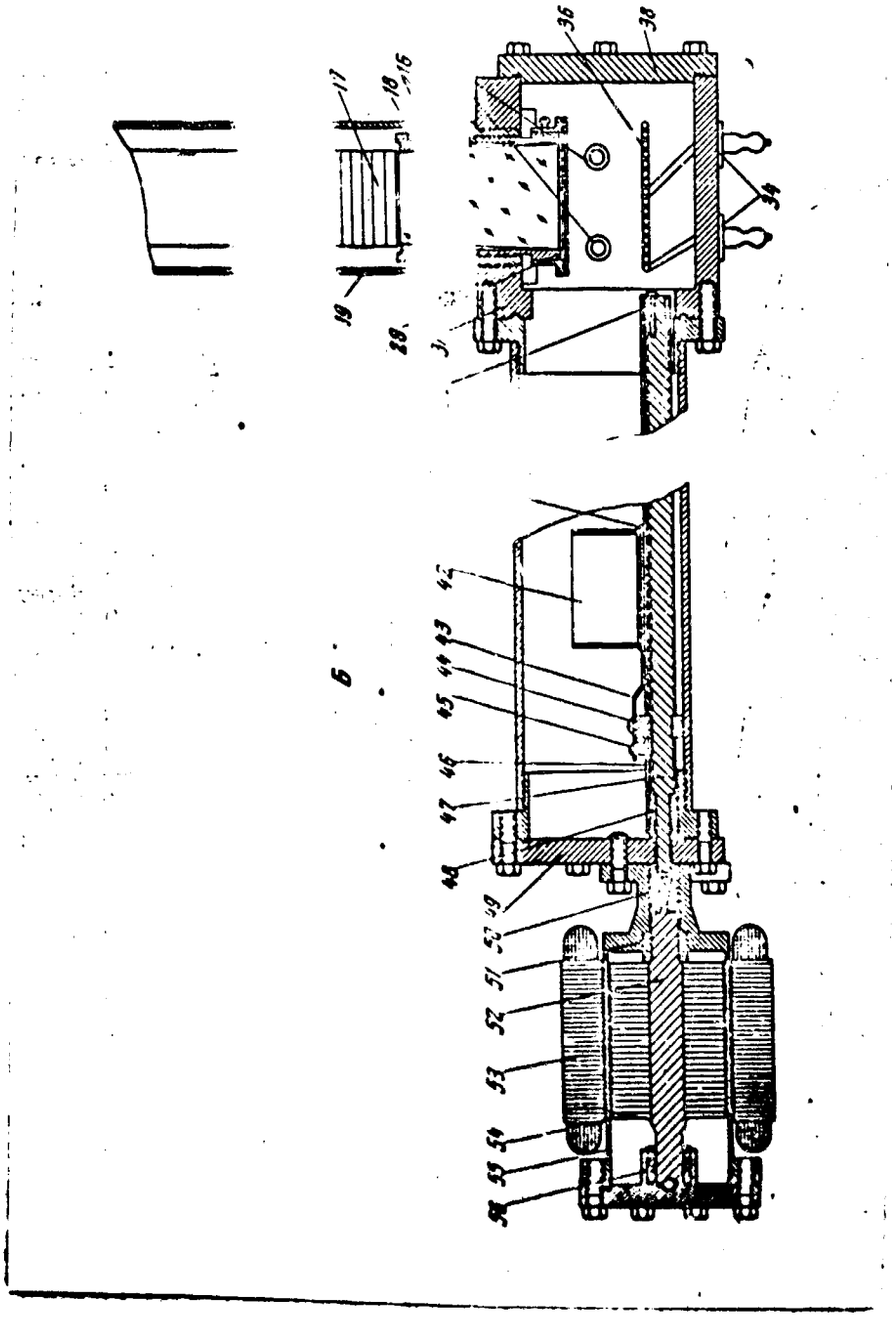

Fig. 1 (2/2)

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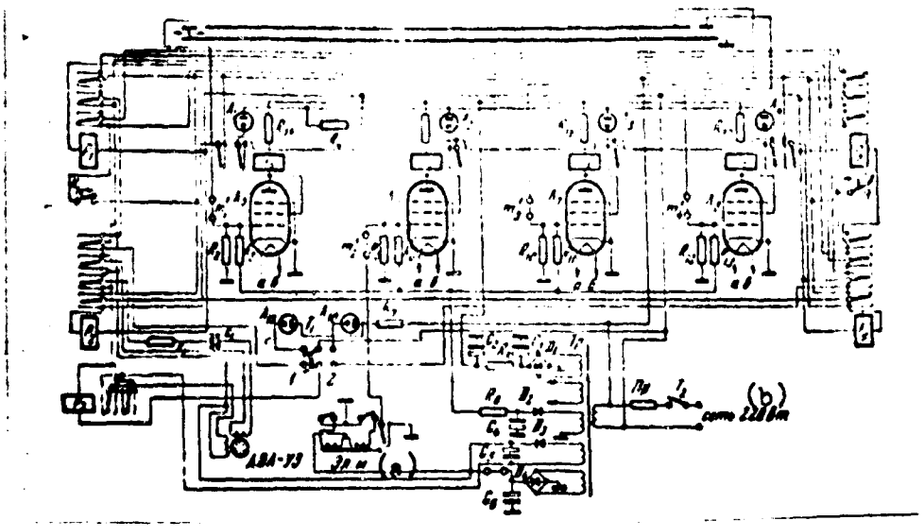

Fig. 2 Basic schematic for chamber control.

R_1 - 500 ohms; R_2 - 56 kiloohms; R_3 - 160 kiloohms; R_4 - 33 kiloohms; R_5 - 56 kiloohms; R_6 - 160 kiloohms; R_7 - 37 kiloohms; R_8 - 220 kiloohms; R_9 - 47 kiloohms; R_{10} - 56 kiloohms; R_{11} - 160 kiloohms; R_{12} - 56 kiloohms; R_{13} - 160 kiloohms; R_{14}-R_{17} - 11 kiloohms; C_1 - 2; C_2 - 40; C_3 - 40; C_4 - 10; C_5 - 600; C_6 - 300; D_1 and D_2 - D7Zh; D_3 - D205; D_4 - D306; L_1 - L_4 - T_H-0.2; L_5 and L_8 - 6P15P; L_9 and L_{10} - T_H - 0.2; P_1 - P_3 -RPT - 100; P_4 - P_7 - RPN.

Key: A - electric motor
B - 220 volt circuit

The second pair of contacts of relay P_4 are used to close relays P_3 and P_2. Relay P_2 serves to change the polarity of the motor and relay P_3 is used to feed direct current to the motor winding. In order to move the dish into the "measure" position button K_1 is pushed. This closes relay P_1 which in turn turns on the motor. Signal tube L_3 turns on when the dish is on the way, regardless of what position the dish is moving toward. When the dish moves into the "measure" position special contacts in the chamber close, tube L_8 goes on which has relay P_7 in its anode circuit. Signal lamp L_4 goes on indicating that the dish in in the "measure" position. Relays P_9 and P_3 are closed. Relay P_9 performs the same function as relay P_2. Signal light L_2 indicates the closing or opening of the PEM blind.

Results of measurement

As the result of a number of model experiments it was determined that the use of this installation makes it possible to record chemiluminescence during the simultaneous operation of various chemical and physical factors which are undoubtedly of value in these studies.

In Fig.3 we see the intensity of luminescence of oleic acid as a function of time; after preparatory chilling to -5° we recorded light quanta reliably exceeding that of the apparatus background. Our data for low temperatures do not correspond to data provided by Zhuravlev [11] in which the luminescence of lipids decreased upon chilling to 20 - 30°. Here, however, the following may be admitted: although the chemiluminescence of oleic acid is recorded at low temperatures, it is possible that this is related to oxidative processes. As in work mentioned in [11], we found identical data for temperatures of 20 - 60°.

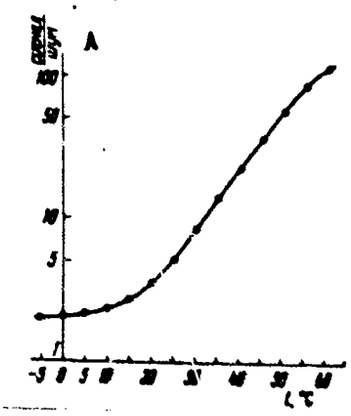

Fig. 3 Intensity of chemiluminescence of oleic acid as a function of time.
Key - A - signal noise

As shown in Fig. 4 when X-rays act in a 2000r dose on oleic acid there is a spurt in luminescence which quickly extinguishes; in this experiment temperature was kept constant at 37°.

According to the presentations of Tarusov [3], an important evidence of radiation damage are oxidative changes in lipids. As seen from the line, even with a 2000r dose there is a spurt in chemiluminescence immediately after irradiation which lasted for several minutes in our apparatus and indicates the possibility of oxidation.

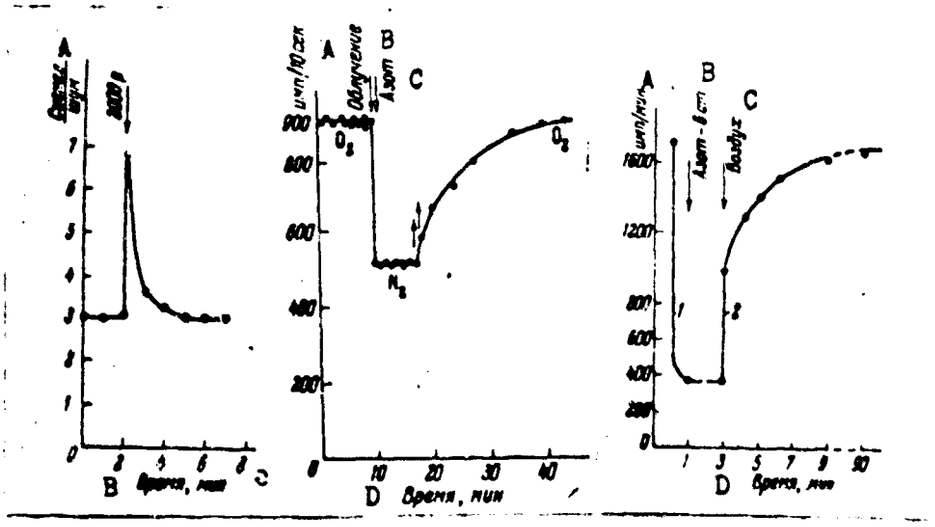

Fig. 4 Chemiluminescence of oleic acid under X-rays
Key: A - signal/noise
B - time in mins

Fig. 5 Change in chemiluminescence of oleic acid with simultaneous effect of X-rays and nitrogen
Key: A - pulses per 10 secs
B - irradiation
C - nitrogen
D - time in mins

Fig. 6 - intensity of chemiluminescence as a function of time in an atmosphere of nitrogen and air
Key: A - pulses per minute
B - air
C - nitrogen - 6 at
D - time in mins

As we know, when biosubstrates are irradiated one may also observe the excitation state in molecules which may produce luminescence in a metastable state. We set up such an experiment with the simultaneous action of two factors: nitrogen and X-rays. It was found that the spurt in chemiluminescence which was observed in an oxygen atmosphere (Fig.4) was greatly suppressed in a nitrogen atmosphere (Fig.5); when nitrogen pressure and X-rays were eliminated and aid fed into the chamber there was a gradual restoration of chemiluminescence.

A single-type line (Fig.6) was obtained in the experiment where oleic acid was acted upon only by nitrogen. Immediately after the oleic acid was placed in the chamber the first chemiluminescence was recorded. Then the chamber was ventilated with nitrogen for 15 minutes after which the pressure was brought up to 6 atmospheres and luminescence was recorded. Although luminescence declined rapidly, it did not reach the level of apparatus background which during measurement time remained constant at a level of 150 pulses per minute. Chemiluminescence was recorded for 90 minutes by turning on the air feed system.

As we can see from the drawing, the line has a two-phase nature - the rapid drop in chemiluminescence [1] and after the replacement of nitrogen by air a slow restoration [2] which gradually reaches the original level. There can be no doubt, these experiments are indications of the possibility and usefulness of the chamber which, as we can see from the data obtained, may be successfully used in biophysical experiments.

* * *

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